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Spectrum Allocation policy for Opportunistic Radio Network with Multiple Primary User Environments

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ABSTRACT

Cognitive radio is upcoming technological trends for exploiting licensed spectrum of radio resources in wireless Communication. Cognitive radio network solves the current problem of inefficiency in the spectrum allocation. It lets the secondary users to opportunistically access spectrum band of primary users to transmit its multimedia data, while protecting PU activity. Spectrum sensing and Spectrum allocation plays an important role in cognitive radio communication. In CR Network life cycle spectrum sensing is to discover spectrum band access opportunities without disturbing the primary user's. Sensing controller that may be hardware or software can control and coordinate the operations of CR network. In this context, matched filter detection technique is considered for spectrum sensing. Matched filter detection technique rely on transmitter detection and its sensing time is very less. The spectrum sensing, determines if a primary user is transmitting or ideal in its own communication band. A new spectrum allocation scheme Predictive Pre-emptive priority PPP is proposed in which spectrum decision is based on the available spectrum characteristics and on the QoS requirement of the secondary user. The system is simulated using the ns2 simulator to know the performance of the system.

KEY WORDS: Spectrum sensing, Spectrum decision, Spectrum sharing, Cognitive radio network, Dynamic spectrum access, Matched filters.

1. INTRODUCTION

Recent technology development in the field of wireless communication was beyond 5g. Major resources for wireless communication includes Spectrum, infrastructure and equipment etc. of which Spectrum is the very limited resource. Spectrum is a scarce resource and allocating these resources optimally to the most demanding multimedia user is a challenging issue in the field of wireless communication technology. The available band width needs to utilize properly and carefully. Already we have unlicensed spectrum and licensed spectrum allocated for different communication purpose like mobile, television broadcasting, radio, satellite communication etc.

Of these allocated frequency band certain bands are either not properly utilized or underutilized. The study of spectrum occupancy measurements of the worldwide available spectrum reveals that only a portion of the spectrum band is used fully. That is due to the existence of certain applications with QoS that demands higher frequency bands in addition to the already allocated frequency band in current system of wireless communication. The major issue is acquiring addition frequency for these kind of application through spectrum reallocation or recycling which leads us to the option of efficient utilization of the limited spectrum resources that are already allocated to various systems which has not been properly utilized.

The telecommunication system can be classified as two networks type, one is primary network formed by the Primary Users (PUs) and the secondary network that is formed by secondary Users (SUs).

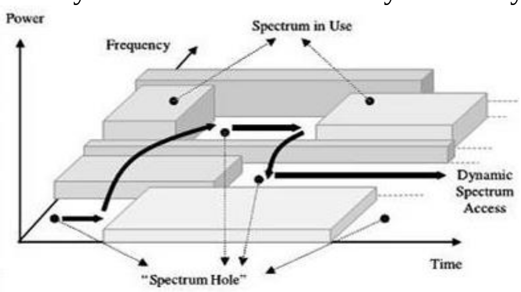

Figure.1. Spectrum whole concept

There are two types of user involve in the cognitive radio network, namely primary user and secondary user based on their access to the network. The classification is based on their access to the network frequency band as well as the based on the payment specification. Primary users are the licensed user who pay for frequency band that is allocated to then, and they are the owner of spectrum band. The secondary users are the unlicensed user who does not pay any amount for their network usage and they communicate with the frequency band of 2.4 Ghz and 5.1 Ghz range.

The under-utilized or partially occupied by low-power interferers or unused primary users bandwidth that is termed as hole gives raise to the new technology of Cognitive radio networks. These spectrum holes are otherwise called as white or gray spaces. The figure.1, shows the spectrum holes created due to inefficient use spectrum band by PUs, that can be used by secondary users using cognition enabled devices. These gray spaces or the holes are occupied by the secondary users to transmit its multimedia data.

The functional components of life cycle of cognitive radio are: Spectrum sensing- Detects under-utilized spectrum and find the available holes in the spectrum. Spectrum decision- Capture already sensed spectrum holes that can satisfy the secondary user required QoS. Spectrum sharing-Provides reasonable spectrum scheduling method for sharing the available open spectrum among coexisting CR users (Arun, 2011). During Spectrum mobility it communicates the requirements of the secondary users as well as the channel activity of PUs so as to maintained communication link while switching to better opportunity.

In this paper the main focus is on Spectrum sensing through matched filter detection and Spectrum sharing technique that efficiently utlize the sensed holes through CR enabled nodes to transmit SUs multimedia data across multiple service providers.

In this new proposed system CR infrastructure needs to be deployed in nodes to gain access to these feature to maintain spectrum sharing by coordinating over different service providers in the same operating environment.

General Analysis: The PU activity in the Cognitive radio network varies quickly in the time domain. In order to use the unused spectrum band of the PU, the SU s within the interference range of the PU need to deploy any kind of spectrum sensing and access schemes with which it will be able to transmit its multimedia data dynamically adopting to the PU s Channel frequency. It is ethical that the SU is not supposed to harm PU communication activity. Any activity overlap of SU over PU in the same spectrum band leads to collision in the channel, which is the conventional measure of PU interference.

Cognitive Radio network life cycle consist of 4 different phases like Spectrum sensing, Spectrum decision, Spectrum sharing and Spectrum Mobility. In the Spectrum sensing the system needs to detect the unused or underutilized spectrum band of the primary user by scanning the CR environment which is a challenging task. The primary user of the spectrum can be detected through various sensing techniques are proposed and discussed. There are different Spectrum sensing techniques of cognitive radio that are classified to be interference based detection, cooperative and non-cooperative technique (Gajanan and Mansi, 2011). Cooperative sensing is a based on the transmitter signal detection technique and non-cooperative is a receiver signal detection technique (Atti, 2012). The three different categories of Non-cooperative spectrum sensing techniques are cyclostationary feature energy detection and matched filter detection (Sheetal and Kamble, 2014).

In Spectrum management phase finds the best available spectrum that matches with the Qos required for communication. The main task of spectrum manager is to ensure fair, open and flexible access to the available grey or white spaces. Spectrum decision, aims at providing the users with the best possible services. The spectrum manager is also responsible for planning ahead, so that new services can be provided as and when required. Thus the main task to ensure the spectrum access by prior planning, regulation is done by spectrum Manager. The application of consistent regulatory procedures can be termed as Spectrum sharing.

The author defines the system (Eric and Xin, 2011), with network consist of multiple primary user and a single secondary user which may be a single CR radio operating within the range. All PUs accesses its pre allocated channel without interfering among themselves and also without the effort of environment sensing. The switching times are often dwarfed by the minimum time of SU demand. There is a risk of performance degradation like latency due to frequent switching between channels. The SU is capable of transmit only on a fixed channel and sub bands of the channels cannot used for transmission. Before transmission the SU senses the channel in each slot using LBT principle. In the existing system, the PUs is heterogeneous in terms of packet collision probability and idle time distribution.

2. SYSTEM DESIGN

The main objective is to develop an intelligent communication network that can adapt to dynamically changing channel conditions by sensing and analyzing the available spectrum frequency band and using these available spectrum holes opportunistically. In this paper the main focuses is on the spectrum sensing method of the Cognitive Radio in order to detect and utilize the underutilized spectrum without disturbing the primary user activity using the matched filter detection technique. In addition we propose a new Spectrum decision technique Predictive Pre-emptive Priority based spectrum allocation scheme.

The proposed system defines the behavior of CRN with multiple secondary users in multiple Primary user environments. Figure.2, depicts the block diagram of the proposed system, which consists of main functional blocks spectrum sensing, spectrum decision and spectrum sharing.

It uses matched filter detection technique to sense the idle primary user. The channel selection is based on Predictive Pre-emptive Priority based spectrum allocation scheme for optimized channel allocation. The rule inferences make the system select the optimum channel for the SU to transmit that aids in throughput maximization (Chen, 2012).

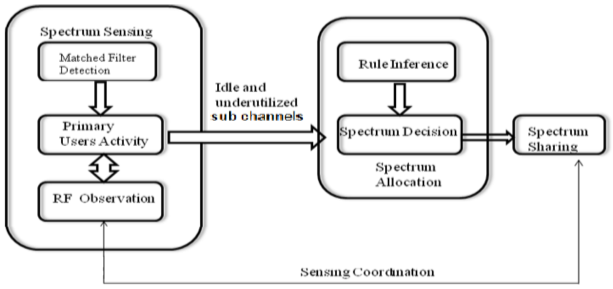

Figure.2. Block Diagram

Spectrum Sensing: In cognitive life cycle the spectrum sensing is the major function which senses the dynamic environment for the unutilized spectrum band which varies in various parameters related to the radio channel characteristics and radio environment. The parameters that has to be sensed in order to detect the presence of PUS are available free channel, the applications that uses it, requirements of the user, and local spectrum allocation policies including other operating restrictions. The spectrum sensing is done across Geographical Space, Time, Code, Phase and available Frequency of networks. Few authors have contributed in the spectrum sensing functionality. (Garima Nautiyal and Rajesh Kumar, 2013; Ashutosh Singh and Varsha Saxena, 2012; Shobana, 2013; Bodepudi Mounika, 2013). These author has discussed about the issues and various sensing scheme were discussed in the research work. The task of the CR user, is to study and scrutinize its local radio environment. Based on these observations of CR user and its neighbors, CR nodes equipped with these facility of sensing and managing scheme can efficiently utilize the spectrum using the any of the method. In this proposed system Matched filter detection comes under Transmitter detection method, and is used for sensing the spectrum.

Matched Filters: In a cognitive nodes, in order to achieve the maximum signal to noise ratio as output for a certain input signal frequency a matched filter is designed which is classified to be linear filter (Wang, 2011). If the node or user has the prior knowledge of the transmitted signal of the primary user, Matched filter detection is applied. If the channel side information like modulation type and order, pulse shaping, bandwidth, operating frequency, and frame format of the of the primary user features known to the receiver (Yucek and Arslan, 2009; Shobana, 2013). Then matched filter detection can be implemented to achieve the desired output. Hence the Matched-filtering method is known to be the optimal strategy for sensing of Primary user activity in the presence of stationary Gaussian noise. The main advantage of matched filtering is, to meet a given probability of detection constraint it requires only O (1/SNR) samples which results in less sensing time of the signal. The important issue with Matched filter detection is, it requires a prior knowledge of PUs transmission criteria.

As shown in Figure.3, a known original PU signals with a received signal. The matched filter output sampled at synchronized timing. Then it is checked if the threshold value k is less than the sampled value Y, indicates the channel is being used by the PU for transmission. This kind of spectrum sensing scheme is termed as optimal detector in stationary Gaussian noise. This method ensures optimum or fast sensing time that necessitates O (1/SNR) samples to accomplish a target of detection probability.

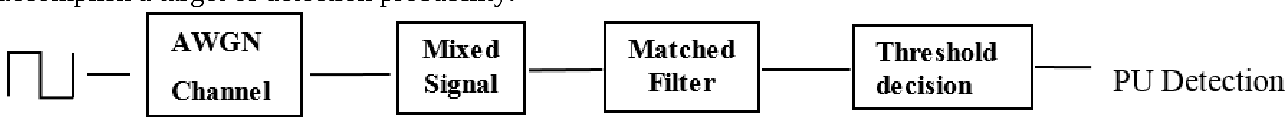

Figure.3. Matched Filter Detection

When the CR user senses more spectrum bands, it is highly probable to detect a better spectrum band while resulting in longer spectrum searching time. The local RF observation used in PU detection sensing is based on the following hypothesis model:

$$r(t) = n(t)H0 \quad (1)$$

$$r(t) = hs(t) + n(t) \quad H1 \quad (2)$$

Where s(t) is the signal transmitted by the PU, r(t) is received signal by the CR user, h is characterized by the amplitude gain of the channel and n(t) represents a zero-mean additive white Gaussian noise (AWGN). H0 is a null hypothesis, meaning that there exists no licensed user signal in a specified spectrum band. H1 is an alternative hypothesis that indicates the existence of PU signal.

Spectrum Decision: Once the available spectrums are identified it is pooled in the Spectrum pool along with all the characteristics. Essentially the spectrum decision should choose the appropriate band that exactly matches the QoS requirement of the CR users. The spectrum band needs to characterized in terms of static behavior of the primary Users and the radio environment. Spectrum decision (Ashwini and Kang, 2010), needs to consider the end-to-end route consisting of multiple hops. Spectrum decision is choosing the right bandwidth for the source destination pair which is based on the routing information along with spectrum selection. To achieve this a novel model PPP- is proposed which is based on the criteria Predictive –Priority - Preempting, that is predicting the PU activity and channel characteristics. Highest Priority is given for Pus activity. Preempting the SUs when the PU resume its channel activity. Given below is a sample extract of algorithm that implements the above model uses the priority based queue for SUs along with its QoS needs also the SU that has been preempted due to PUs interference. And the spectrum pool is organized to be of circular queue where unused PU channels detected using Matched filter detection are added to the front of the queue and the allocation of the spectrum will be assigned on the rear end. In this we take multiple primary user and single secondary user environment.

Algorithm: Spectrum Allocation

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Step 1: for each sub channel of primary user repeat following steps.
Fori= 1to m(m- total no of Primary user channel)
Begin
If (Puch(i)  < Threshold)      {No activity found in the channel }
Pool(rear)= Puch(i){Added to the spectrum pool}
J=0
While (j<=n)n (no of secondary user which needs to transmit with the specified QOS)
Begin
If(char(Puch(i)>= qos(such(j)
{
Assign the Such(j) = Puch(i)
Channel allocated
Channel can be utilized for transmitting Su's data
Go to step X
            }
J=j+1
End
End
```

Many CR users compete to gain access to the available spectrum. In order to prevent collisions there transmission should be harmonized. Spectrum sharing facilitates spectrum resource allocation opportunistically for multiple secondary users. After allocation if the CR users identify that the Primary user uses a specific channel of the spectrum, immediately the CR users vacate from the channel at once and can resume their communications in some other vacant channel of the spectrum. In order to restore the communication the CR user should either find new spectrum band or the same channel may be continued when there is no activity in the channel. This switching mechanism termed to be spectrum mobility that needs a spectrum handoff scheme which performs the transmission switching from one channel to other needs to be of less quality degradation.

There should be proper co-ordination with spectrum sensing in physical layer, neighbor discovery in the link layer, and routing protocols. Besides, available spectrum bands in CR networks differ from one hop to the other. As an effect, the connectivity is spectrum-dependent makes it challenging to determine the best combination of the routing path and spectrum which is beyond the scope of this system.

Since the spectrum holes available have is of different characteristics that vary over time. Each spectrum hole should be characterized for throughput maximization (Amit, 2011), by considering both the time varying radio environment and the spectrum parameters such as operating frequency and bandwidth.

3. NUMERICAL RESULTS

With the existing Ns2 simulator CRN cannot be easily implemented. Hence, it is essential to upgrade the existing simulators to support cognitive radio. We make use of existing NS-2 to extend it to support cognitive radio network simulation. Using the Ns2 simulator we simulate the Cognitive radio network environment with CRN patch which supports CRN. The Cognitive radio algorithms for channel detection and channel allocation can be implemented in the simulator. On running the script file in the terminal many output files are generated. Trace output file, Nam output, Traffic file, Channel file, IT file are generated. Each node over each channel is associated with various interference information. The nodes provide different interference information which is classified as (a) Channel with minimal interference, (b) Current interference value over a specific channel and Historical interference information. To extract information regarding the channels, the algorithm can be transformed into corresponding API and can be used by the user.

Figure.4. Packet loss over Time

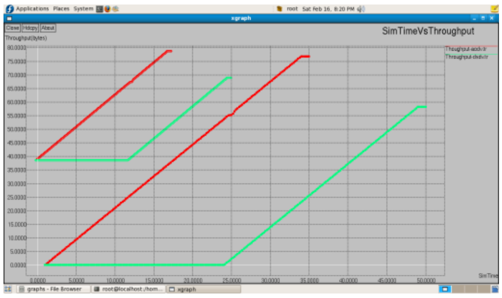

Figure.5. Performance graph

Figure.4, depicts the performance graph. The performance graph is derived from the generated traffic file. Taking time and throughput for two different routing algorithm shown in the figure.5, which shows that the throughput has increased when implemented with PPP model to an expected increase in, throughput up to fifteen percentage in the simulated environment.

4. CONCLUSION

The proposed method focus on the behavior of multiple secondary users in the multiple primary user environment. Matched filter is used for spectrum detection technique that reduces the sensing time. The efficiency of cognitive radio depends on the effective spectrum sensing. When considering the spectrum decision the time complexity of the proposed algorithm is negligible. Our ultimate aim is to utilize the underutilized spectrum efficiently without interfering with the primary user which is achieved with the above PPP methodology. In future instead of using matched filter, Cyclostationary Analysis can be used for channel sensing. The above result of Simulation demonstrate, that a significant improvement of detection performance had been accomplish when combined with the proposed spectrum decision method.

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